The Life of Insects

T. N. Ananthakrishnan

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FOREWORD

We are living in an age of technology. Both science and technology are growing rapidly. Everything about science cannot possibly be told to a student at school or college Consequently the investigatory approach when adopted is the only way to arouse the curiosity of the learner and enthuse him to acquire knowledge far beyond the rigid boundaries of a curriculum. To meet this requirement, there is need to provide adequate supplementary reading material written in a manner intelligible to a student Such material can arouse his curiosity and also quench his thirst for more knowledge

The National Council of Educational Research and Training has undertaken the task of preparing supplementary reading material on topics which do not strictly fall within the school curriculum but which have a bearing on what the student learns at school The present publication is one of such volumes It tells the child about the life of various insects and enriches his knowledge of natural history. It is hoped that this publication will be found useful by both the students and the teachers.

New Delhi
31 *December* 1969

S V. C. Aiya
Director

INTRODUCTION

THE aim in introducing a series of booklets on various topics of biological interest has been primarily to focus attention of a growing child in school to new biological horizons. At the same time, we felt that such knowledge could be equally useful to any one who is not particularly a biologist, either by training or profession.

Projecting a series of booklets for divergent age groups is not an easy task. Yet, the vast resources of scientific talent available in this country has made such a task possible.

The first of the series of titles in biology relates to 'The Life of Insects.' Of the vast array of living beings, both plants and animals, insects perhaps are astonishingly large in numbers and variety and, indeed, the ways and means by which they have adapted themselves for life on earth in different environments is a fascinating story. It is not a paradox when stated that they are perhaps the most successful group of active animals which have survived time and space and have evolved to their present state. Their small size, their rigid body, impervious to water, all seem to contribute to greater success as living beings. Many of them are useful for our welfare but many more are harmful. Between these two extremes are also a range of those that cannot be classified into either of these categories.

Prof. Ananthakrishnan is an entomologist of repute with a distinguished academic career. His entire research career has been devoted to the study of insects and it is fortunate that he is the author of the first title in the present series.

It is hoped that the response to this booklet both from the child at school, the parent and the man at work, would be encouraging and goad us to project equally important titles in this vast effort to disseminate useful biological knowledge

University Botany Laboratory
Madras 5
7 January 1970

T. S. SADASIVAN
Professor, Madras University
and Convenor Biology Study Groups
NCERT

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1

What are Insects?

NO ONE can deny having seen such creatures as the cockroaches, grasshoppers, butterflies, dragonflies, bugs, ants, mosquitoes and flies which offer a familiar everyday sight. Collectively we call them by the generalised term 'insects'. In ordinary language it is difficult to define them, because the name 'insect' is usually associated with some unpleasant creatures, fit only to be destroyed at first sight. There is hardly any place in the world where they are not found—in air, water, on land, beneath the soil, in decaying animal and vegetable matter. From the equator to the poles they are distributed everywhere. Even snow and ice do not diminish their activity and they are seen even in hot springs, salt lakes and pools of petroleum. They become very conspicuous because of their ability to multiply in large numbers and they easily outbeat all other animals in their numbers. To give a simple example, an ant hill contains two to three times as many ants as there are human beings in a city. It is alarming at times to observe huge armies of caterpillars marching into paddy or sugarcane fields or the huge swarms of grasshoppers called 'locusts', sometimes estimated to contain over 1,500 million individuals. In size they range from one hundredth to about ten inches long and the largest insect is about the size of a small rat, while the smallest insect is about the size of a large bacterium or an amoeba. Naturally when these insects abound in such large numbers, their habits become very varied. Some of them bite and cut leaves, stems and roots, others pierce and suck the sap of plants or human or animal blood, yet others feed on decaying organic matter, and still others prey on other insects. The lives of some of the insects are closely associated with that of man, levying a heavy toll on his personal belongings. These include the pests of crop plants and stored products, the disease carriers and the domestic insects found in human dwellings such as the cockroaches, crickets, bugs, houseflies, mosquitoes, clothes moths, silver fishes and so on. Though man always considers himself superior in every respect, there is little doubt that he is actively competing with insects to save his crops and so his food.

To know an insect better, it is necessary to have a brief idea of their general body pattern. The word insect means 'cut into' and refers to the division of the body into a number of parts or segments. All insects have their bodies divided into three main parts—a head, a thorax made of three parts or segments and an abdomen usually made up of ten segments (Fig. 1). The head

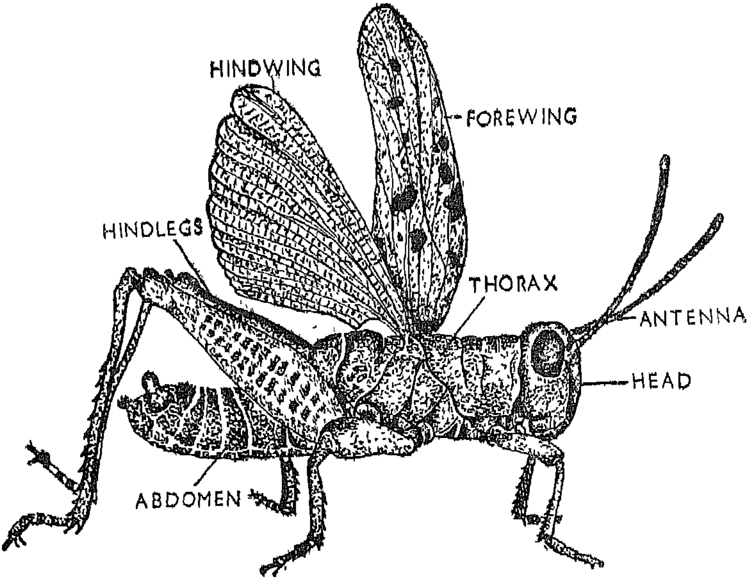
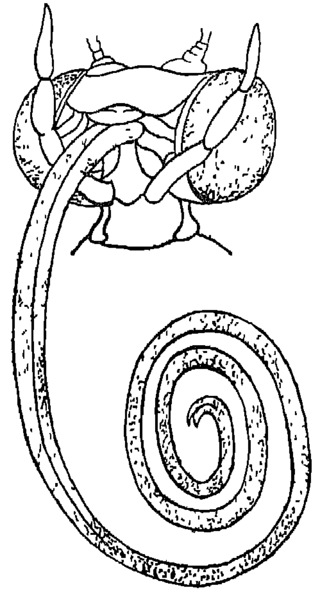
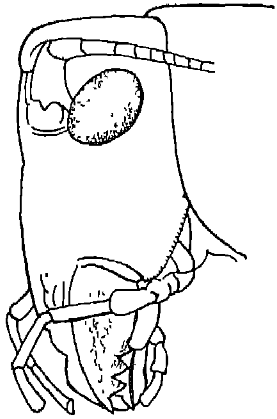


Fig. 1. Grasshopper

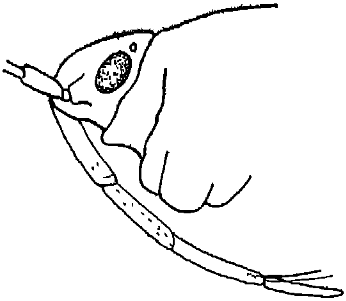
bears a pair of large compound eyes made up of several smaller units or facets, a pair of feelers or antennae and the mouth parts including the lips and the jaws, useful in feeding. Each segment of the thorax bears a pair of five-jointed legs. The body is covered by a hardened outer shell made up of a substance called *chitin*. Unlike the vertebrates or backboned animals, there is no skeleton within the body. Because the outer skin is hardened it gives the needed protection. This outer chitinous shell has some remarkable properties combining great strength with lightness and in addition to protection, helps in preventing loss of water from the body and is also highly resistant to chemicals. The division of the body into parts, allows



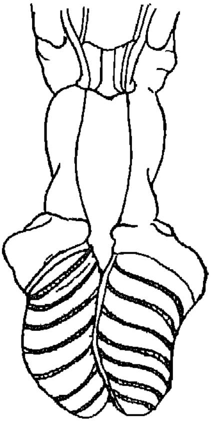
Butterfly



Grasshopper



Bug



Housefly

Fig. 2. Mouth parts

great freedom of movement and permits each part to carry on its function.

To be able to live successfully in the surroundings the mouth parts, legs and wings undergo diverse modifications. The mouth parts are adapted for biting in the cockroaches and grasshoppers, only for sucking in the butterflies and moths, piercing and sucking in the bugs and mosquitoes and for licking in the flies (Fig. 2). Take a grasshopper or a cockroach, you will find strong, toothed jaws which work from side to side and crush the food; or a mosquito or bug, which have sharp piercing needles for piercing the skin and sucking the blood. The butterflies and moths have a long grooved coiled proboscis or sucking tube, serving to suck nectar from flowers.

The jointed legs, though normally a device for walking or running, may also become modified for a variety of purposes, such as leaping or jumping as in grasshoppers or crickets, for swimming as in some water bugs, grasping as in the preying mantis, digging as in the mole crickets (Fig. 3) clinging as in the head louse, or for cleaning or carrying loads of pollen as in the honey bees.

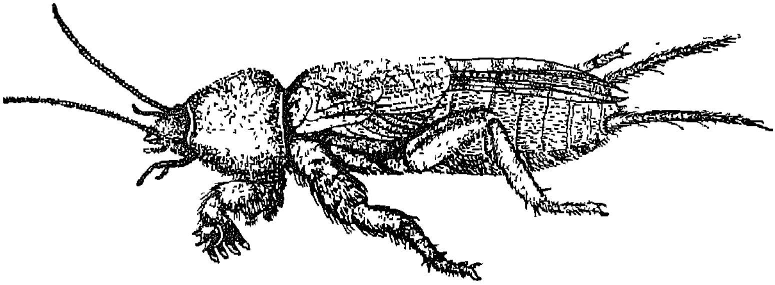


Fig 3. Mole cricket

The sensory feelers or antennae and the compound eyes may vary greatly in size, shape and form. The feelers may be thin and hairy, club-like, bead-like, leaf-like or comb-like. The compound eyes which are the main organs of sight, are composed of tightly packed units or facets, varying in number from ten to over thirty thousand. Each facet is called an *ommatidium* and has a complicated structure comparable to the human eye. Because of the very large number of such facets, a combined effect is produced.

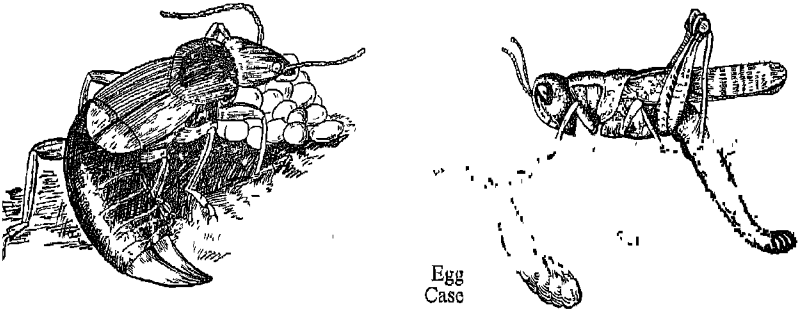
Sensory hairs are most numerous on the antennae and it is a common sight to see many insects like the ants, testing the ground before them with their antennae. The sense of taste and smell is also believed to be on the antennae. The sense of smell appears essential to many insects for attracting the opposite sex, for recognizing the odours of their own kind as in the case of ants which follow trails laid down by other ants In the male mosquitoes and in ants, the hairs on the antennae are specially developed for the purpose of sound perception. Organs of hearing are not present in all insects, but all the same some insects show response to sound. Many make use of the hairs on the body. Special organs of hearing are present in many grasshoppers and crickets and are called the *tympanal organs* Like the ears of higher animals, they have a tympanum or drum connected with the nervous system. The grasshoppers have them at the base of the abdomen unlike the crickets which have them on their forelegs.

The wings of insects enable them to fly and they are the only winged invertebrates or backboneless animals.

The wings are outgrowths of the thorax and are usually membrane-like, supported by a series of ribs called veins. These veins are thicker and are close together at the base of the wing. In some insects like cockroaches, grasshoppers and crickets, the front pair of wings are more leathery. In the beetles, the forewings become hardened and stiff to form the elytra. The wings move with an up and down beat combined with a twisting at the base. To be able to move about quickly from place to place during flight, it is essential that both the pairs of wings work together. For this purpose there are excellent adap'ations for locking the wings of each side together so that they function as one unit. By varying the angles of the wing blade and the frequency of the wing beats, insects have achieved elaborate control with regard to the speed and directions of flight. In this connection mention may be made of the bees which are expert fliers. Not all insects possess wings and in such insects like the silver fish, lice, some bugs, ants and flies, wings are absent. When present, there are usually two pairs, but in the flies and mosquitoes there is only one pair. In some moths the wing span may reach ten inches but only one hundredths of an inch in some tiny flies.

The abdomen, unlike the head and thorax, is constituted on a different plan. It has to be extensile for two main reasons, to store and digest the food in the abdomen and for egg development in the females. This expansion is made possible by the presence of thin membranous areas between the segments. At the sides of the abdomen and thorax are paired openings for the intake of oxygen. Insects whose young ones live in water have special structures called gills projecting from the abdomen laterally or at the end of the body.

A majority of insects lay tiny eggs from which the young ones come out. Some insects also give birth to young ones directly. The egg laying capacity differs with different insects and may range from 1 - 1,000,000. The eggs are of various sizes, shapes and colours. Insects like the butterflies lay eggs in groups, openly on the surface of leaves; others lay them inside the tissues of plants or in slits on stems. Some aquatic bugs carry their eggs on their back or as in the case of mosquitoes lay their eggs on the surface of water either singly or in a mass. They are usually unsinkable and unwettable. Insects like the cockroaches and the preying mantis lay their eggs in a protective egg case. In the case of the grasshopper and earwigs the eggs are laid deep inside the soil or near the surface beneath stones (Fig. 4). Certain others lay eggs within the eggs or bodies of other insects and these are called parasites.



Earwig with eggs

Fig 4.

Grasshopper laying eggs

The young cockroaches, grasshoppers and bugs coming out of the egg are without wings and resemble the adults in general appearance. As they feed and grow, they shed their skin from time to time because of their enlarging body. This casting off of the skin is called *moulting* and has to take place periodically because the external chitinous shell is rigid. The wings develop finally and the young ones become the adult. In others like the butterflies and moths, the young ones coming out of the egg are totally different from the adult in appearance and are called the larvae. The larva coming out of the egg of a butterfly is called a *caterpillar* and that of the beetle is popularly called as a *grub*, while the larva of a fly is termed a *maggot* (Fig.5). The caterpillar has three pairs of jointed legs in addition to five pairs of fleshy legs on the abdomen; in the grub

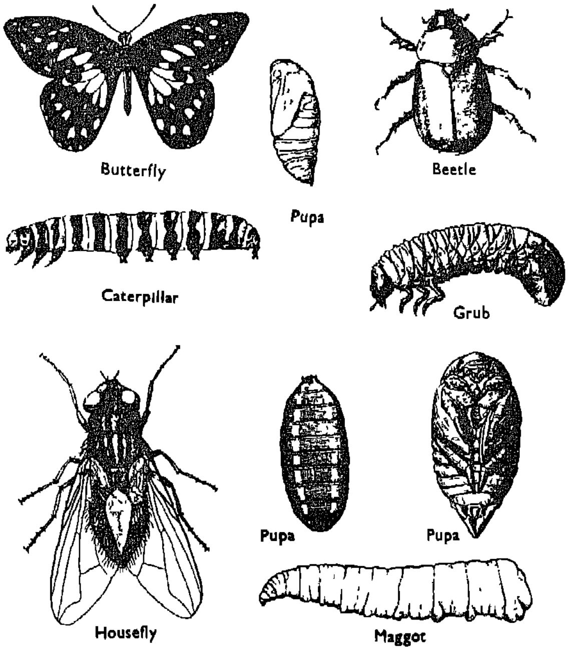


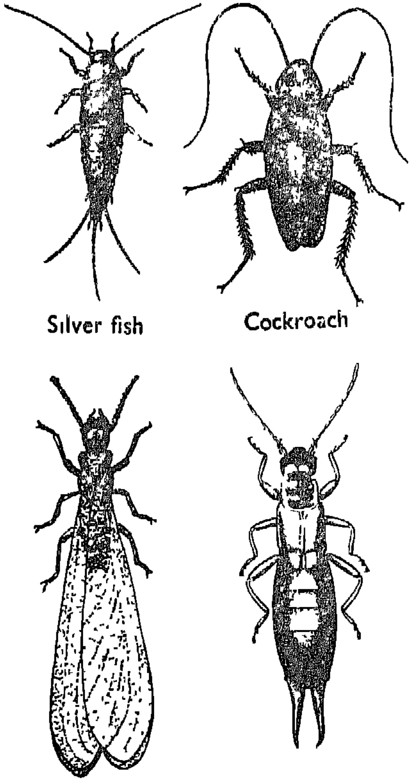
Fig. 5.

the abdominal legs are absent, while the maggots are totally legless. These feed and grow and shed their skin and before becoming the adult, they enter a resting stage or the pupal stage. The larvae of all insects undergo a number of moults before they are fully grown. The formation of the pupa or pupation may take place within a covering or pupal case, secreted by the larva. It will be of interest to note that it is from the cocoon of the silk moth that silk is obtained. It is in this pupal stage that the larval body is transformed into that of the adult. This gradual change of form has been termed metamorphosis.

2

The Variety of Insect Life

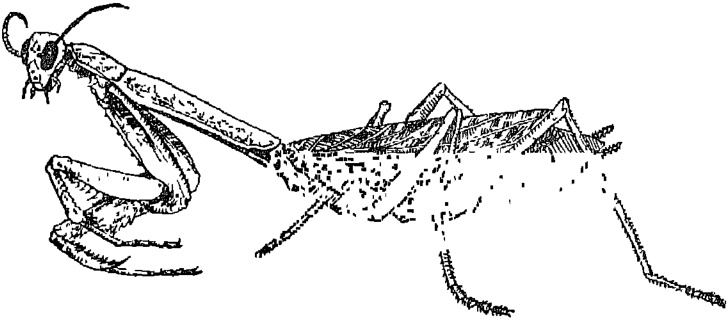
IT WAS mentioned that insects are found practically in every habitat and in order to be able to live successfully in these habitats, they possess excellent adaptations. The majority of insects feed by sucking the sap of plants or animal or human blood; or biting and chewing the various plant parts like the grasshoppers, caterpillars and beetles; or are omnivorous, feeding on all sorts of food materials like dead animal matter, food products, woollen goods, gums or paste from bindings of books. These live in dark corners such as kitchen shelves, or drainage lids. The well-known silver fish, a primitive wingless insect with a glistening silver appearance and running swiftly at the slightest disturbance, is a domestic creature frequenting the binding of books, on the wall behind calendars and photos and old clothes and causes sufficient damage. Some insects are carrion feeders, feeding on dead insects or animals. Others attack the dried products of animals such as skin, feathers, and hair. In tanneries where hides and skins are processed several skin beetles are met with. Costly articles like carpets, woollen goods are often seriously damaged by the carpet beetles. Some are scavengers and the dung rollers which roll dung into tiny balls and drag them to their burrows, are a common sight (Fig. 6).


Silver fish Cockroach

Winged Termite Earwig

Fig. 6.

While the above mentioned insects are free living, some insects called the predators feed on other living insects. Others called the parasites, usually lay their eggs on or within the body of other insects and the large number of young ones coming out cause the death of the host. Insects like the praying mantis, dragonflies, lady birds and tiger beetles are predators which kill the prey outright and feed on them. The forelegs of the mantis are armed with strong spines folding like the blade of a pocket knife and



Praying Mantis

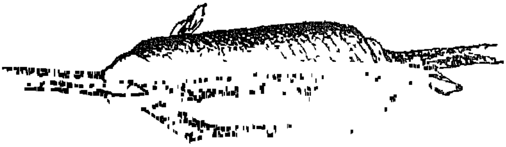


Fig. 7. Egg case

are adapted for holding and crushing the prey (Fig. 7). Dragonflies capture flies and other small insects in the air. They swoop on their prey like tiny hawks. The victims are caught by the legs which act as fly traps and then taken to the mouth. The larva of the dragonfly lives in water and is very ferocious, feeding on all kinds of small animals like small insects, tadpoles and tiny fish. There is an excellent adaptation for feeding. The lower lip is enlarged and is about half the length of the body and is provided with sharp teeth at its end. This special mask or hood is kept folded against the mouth normally, but as soon as it comes across the victim, it suddenly shoots out its mask, grasps the prey and takes it to the mouth (Fig 8). The common lady bird beetle is also a good example of an insect which lives on animal food. The larvae and adults freely prey on other insects. The tiger beetles, well known for their handsome colouration form another example

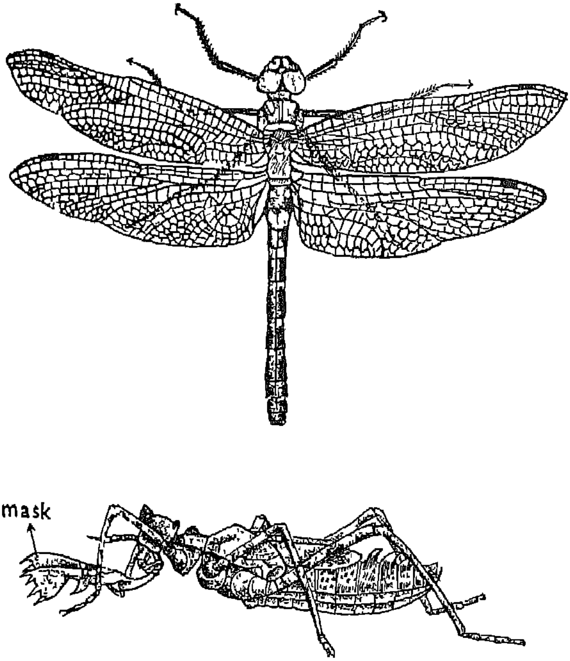
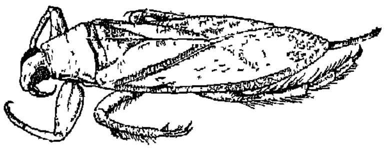
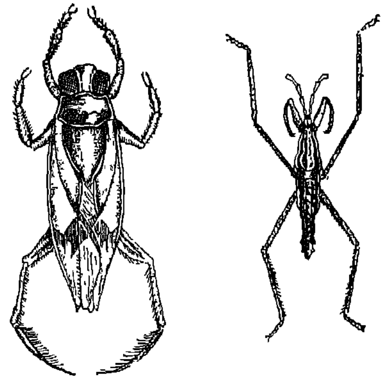


Fig. 8. Dragon flly—adult and larva

Several insects live in lakes, ponds and streams and very few are found near the sea. Some like the dragonflies, mosquitoes and mayflies spend only their early stages in water, while the adults live in the air. Others like the water scorpions and giant water bugs are permanent inhabitants of water. They have excellent adaptations for locomotion, respiration and egg laying. In many aquatic insects the legs are specially modified for swimming and are very much elongated and flattened from side to side with closely set swimming hairs. They have also adaptations to prevent water from entering the body and the closely set fine hairs covering the body prevent it from being wetted. The pond skaters move about on the water surface and are supported on the surface by the surface tension of water. Some of them have long legs and crawl about on the water surface; others use the middle legs together in leaping and are steered forward by the hind legs. Another category includes the back swimmers or water boatmen which use their hind legs as oars. Some like the water scorpions walk about on submerged vegetation (Fig. 9).



Giant water bug



Back swimmer Water strider

Fig. 9.

Some insects like the tiny green leafhoppers and some caterpillars roll or curl the leaves of plants and take shelter inside. They lay eggs inside the leaf rolls and development of the eggs takes place within them. Yet others cause abnormal growths called galls on the stem or leaves and such insects are called gall forming insects. The galls are used for egg laying and the development of the young ones and serve both as shelter and food for the developing young. Termites, ants and some beetles bore into dry wood. Many insects live underground or beneath the soil, rich in decaying organic material. Some like the ant-lions called as the demons of the dust, prefer loose sandy soil and make triangular pits or traps and lie in waiting at the bottom with their sharp jaws ready to pounce on an innocent ant or other insects which fall inside. While many insects live beneath the soil, some like the grasshoppers, earwigs and some beetles lay their eggs in the soil. The ants and the termites or white ants build huge ant hills which consist of numerous galleries within which millions of individuals live.

There is a tendency among some insects to associate in groups as observed in swarms of bees or locusts or caterpillars. Some of them migrate over long distances and good examples of these are the butterflies and locusts, the latter covering thousands of miles. They are carried by their own flight or through the effect of the wind. After a certain height when the wind velocity becomes high they are drifted along. Insects which swarm are known to collect temporarily, mostly for mating purposes. A more permanent association is found in insect communities such as the common plant lice (aphids) seen on the bean plant where hundreds of individuals in all stages of development live together for food and chances to mate. Each individual of the community is independent. There is another mode of living wherein the individuals of a community are mutually dependent and establish well defined colonies. Each individual in the colony has a definite duty to perform. In other words there is what is called a division of labour. Notable examples of such insect societies are seen in the honey bees, white ants or termites and ants. All these live in large colonies comprising thousands of individuals and have a system of castes, namely the queen which is an egg laying machine, the drones or the males to fertilize the queen, the workers for building up the nests, taking care of the developing young and food collection. In the white ants, however, there are also the soldiers which defend the colony from outside attack (Fig. 10).

The termites usually build nests beneath the soil and gradually go on extending it high above the ground. Some nearly reach more than 3-6 metres high and in extreme cases may be ten metres high and 3-5 metres across at ground level. They are so hard that it is sometimes difficult to cut them open even with an axe. One can easily compare these termite mounds to pyramids built by man. Like pyramids they have characteristic shapes, a huge number of termites being involved in one of the finest examples of co-operative endeavour. Inside these mounds are a complex set of internal passages and galleries communicating at numerous places with one another. The queen termite is of interest in that its abdomen is several times longer than the head and lays several thousands of eggs per day. In some termites, it is nearly twenty thousand times the volume of a worker. The queen lays thirty to fifty thousand eggs per day. It has also been calculated that in an year it lays 10,000,000 eggs and 100,000,000 eggs during her life time. It is also interesting to note that feeding in the colony is peculiar and the food is passed from individual to individual by the mouth.

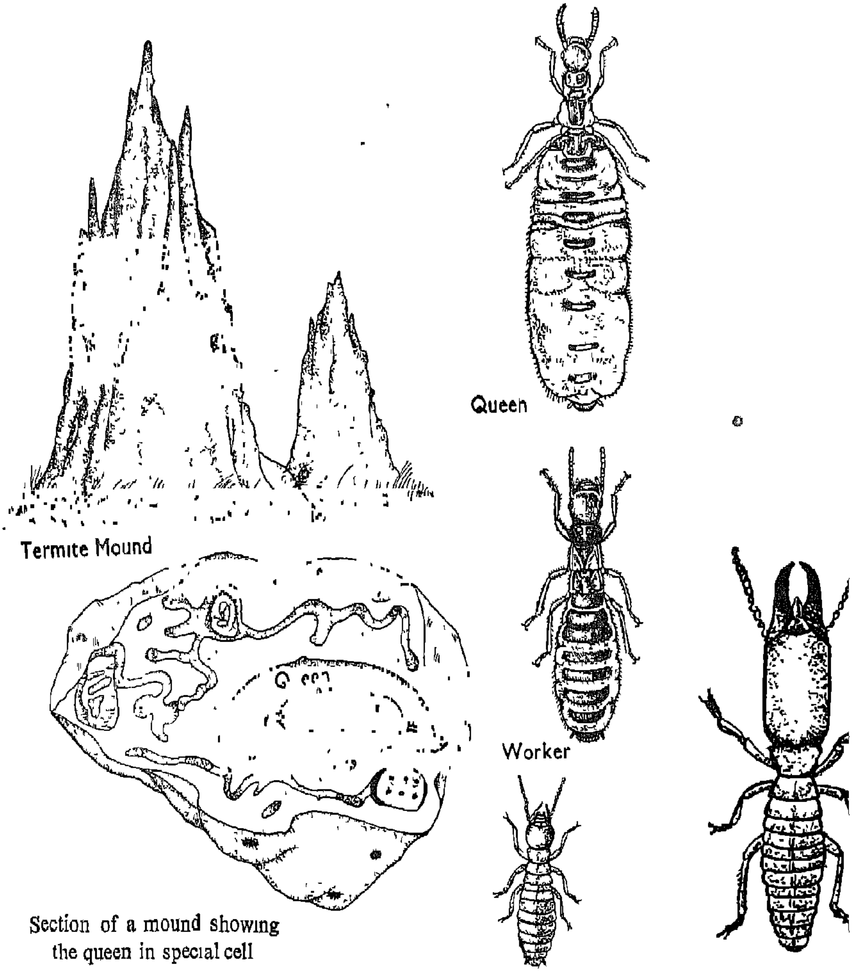

Queen
Termite Mound
Worker
Section of a mound showing the queen in special cell
Soldier

Fig 10. Termites and their nests

Ants provide the best example of a vastly populated community, and in the way they have perfected this community life they are said to approach human societies in many respects. Like termites the ant nests may be below the ground or on the ground or partly above and partly below. It may be on living trees or in decaying wood. Some of the ants have established food stores, others tend and milk ; the worker ants obtain honey dew from aphids and they keep and tend colonies of aphids as if they were herds of cattle, for their honey dew (Fig. 11). Some called the fungus ants rear fungus gardens in their nest ; the slave ants are used in waging wars with other colonies ; yet others send out armies to explore and forcibly bring stored food from other colonies. They guard their nests very well and prevent invasion from other colonies. When their colonies become over-populated they also swarm out and form new colonies. It is only during this period that the queen ant has wings and after mating, the queen ant lands and breaks off the wings. The social ants and termites seem to have solved the problem of over-population ages ago, because reproduction in their colonies is confined only to a single female or a couple of females.

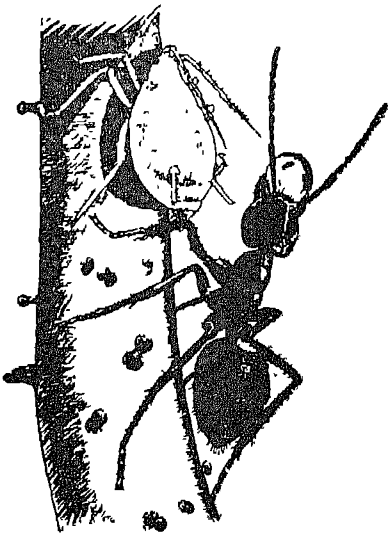


Fig 11 Ant tending aphid

A honey bee colony or a bee-hive is made up of the queen, about ten to hundred male drones and twenty thousand to eighty thousand workers. The queen and the drones are fertile, while the workers are sterile and build the hives. The hives consist of hexagonal cells made of wax secreted by some cells of the abdomen. The queen bee lays one egg in each cell and the hatched young is fed by the worker. The richness of the food source or the information as to the place where abundant food is found is given by the worker to other workers in the colony by a side to side dance called the abdominal dance. The duration of the dance is said to indicate the distance of the food source. Sometimes more than one queen is produced and when the honey comb becomes over crowded one of the queens along with some drones and workers move out or swarm to find a new colony or hive.

The wasps, closely related to the bees, are of interest because they may lead a solitary or social life. The common solitary wasp or the mason wasp is powerfully armed with sting and poison It makes a nest of mud in the shape of a dome, with a circular opening at the top. The eggs are laid within this nest. Soon the wasp goes in search of caterpillars, paralyses them with its sting, and carries it to the nest. It finally closes the opening of the mud cell with clay. When this first nest is complete it goes to build another (Fig. 12).

The potter wasp is common on the roofs of our buildings and occurs as clusters of pots, four or five in number and all of them nearly attached and parallel to each other. Each pot is like a bird's egg and is also

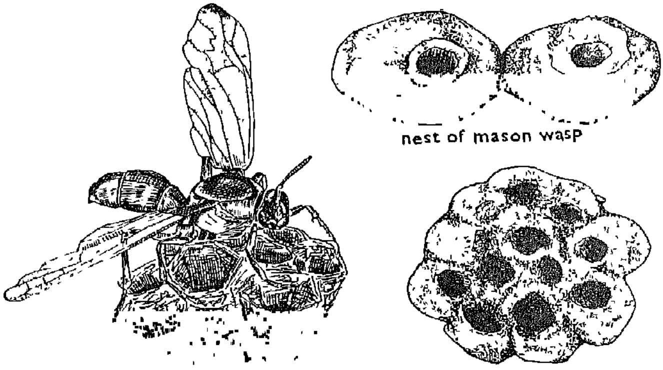


Fig 12.

Paper wasp

Nest of Potter wasp

made of mud. Another category of wasps is the paper wasps with common yellow and black colouration choosing the roof of an open place to build a comb. The comb is peculiar in that it is thin, made of wood chewed with saliva.

3

Injurious and Beneficial Insects

INSECTS affect man both for good and evil, but invariably the harmful insects tending to damage or destroy his personal belongings always take the upper hand. No one can deny the vast potentialities of insects for destruction, taking into account their great numbers, endless varieties and a multitude of habits. Man is indirectly responsible for the capacity of insects to become pests because he constantly interferes and tries to control nature in various ways. Their ability to adapt themselves to their surroundings is unrivalled and therefore pose a serious threat to human existence because they compete with man for food. An insect or two in a field is of no concern but millions of them invading the fields, unless checked in time can cause wholesale destruction of crops. The ever-increasing production by man of countless varieties of insecticides to fight these insects is in itself sufficient proof that man is very conscious of his insect rivals.

Insects cause injury or become destructive in numerous ways. There is hardly any cultivated plant which is not attacked by some insect or other. Some of them like the caterpillars, grasshoppers, earwigs and beetles injure all kinds of growing crops and other valuable ornamental plants by chewing the tender growing leaves, stems, fruit. Insects like the green bugs and leaf hoppers (Fig. 13) pierce and suck the plant sap by means of their slender, needle-like piercing organs and suck the plants dry. Locust plagues estimated to fly in huge columns several miles long, are a source of great danger to crops and since each locust eats its own weight of vegetation the total loss due to feeding by the entire population is staggering indeed ! The earwigs, easily recognized by the pair of foreceps at the end of the abdomen, also play their

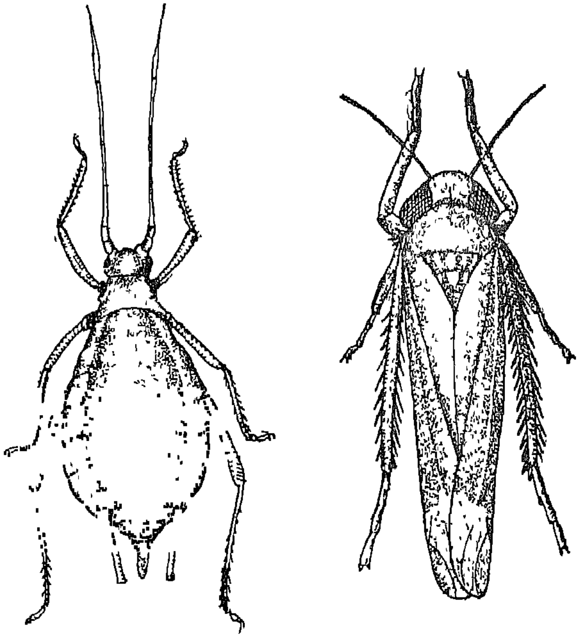

Aphid Leaf hopper

Fig.. 13.

part in causing a good deal of damage to garden plants. In some cases caterpillars and beetles bore and make tunnels inside the growing stems as seen in the paddy plants and sugarcane and other cultivated plants. Some of the smaller green plant bugs called aphids or plant lice and leaf hoppers carry and transmit various kinds of bacterial, fungal and virus diseases, through the wounds inflicted on plant and cause destruction to crops. In all these cases the insects acquire these pathogenic organisms from an infected plant and when they feed on healthy plants, transmit the infection to them (Fig. 14).

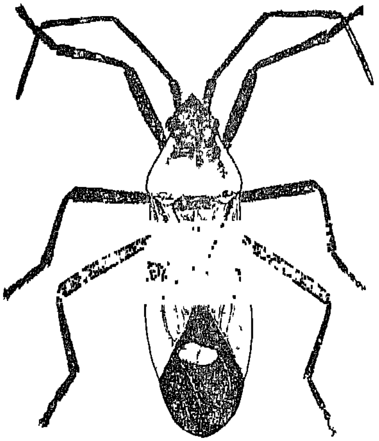
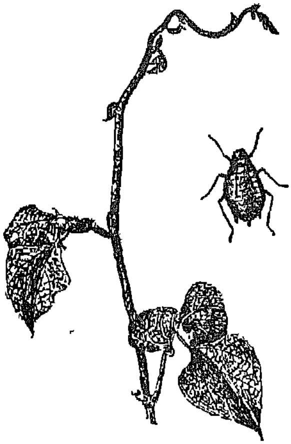


Fig 13A. Plant bug

Insects also cause serious damage to household articles and stored products. It is not always possible to utilize completely the food from a harvested crop. So it has to be stored for months and during this period it is liable to much damage from insects Several millions of rupees are lost every year due to insect attack on stored products. The chief stored products damaged heavily are paddy and other foodgrains, flour, nuts and fruits, tobacco, leather goods, paper, etc. In the case of insects damaging foodgrains, the eggs are laid within these seeds and when they grow the young ones come out and injure the crop. Others contaminate the food with their eggs and excreta, so that the food becomes unfit for consumption.

The termites or white ants are well-known for their destroying powers and eat away huge stocks of paper and badly damage timbers. Though the damage is smaller in magnitude, the silver fish, if unnoticed eats away the book bindings, photographs and even books. The cloth moths have been known to eat away portions of valuable woollen clothes stored up without use.



Bean plant showing aphid attack

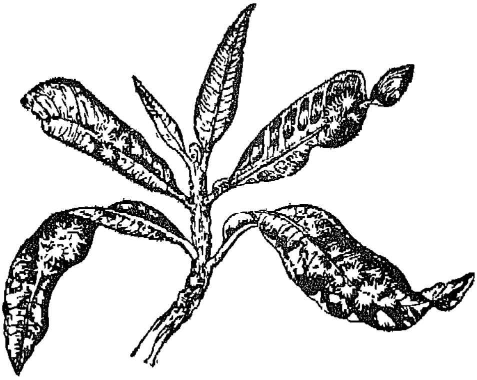


Fig. 14. Garden croton attacked by scale insects

Insects also act as carriers of disease organisms in both man and animals and cause severe loss of life. Mosquitoes occupy an important place in disease transmission because they affect human welfare. They are the carriers of several disease producing organisms and cause such diseases as malaria, filaria and dengue fever. Fleas transmit the deadly plague or black death, which ranks as one of the scourges of the human race. Plague frequently occurs in severe epidemic form and results in the death of large numbers of human populations. The causal organism is a bacillus and spreads to man from infected rats by way of the fleas. As such the death-rate of both man and rats are high. House flies because of their filthy feeding habits carry the germs of diarrhoea, dysentery, cholera and typhoid. In some seasons they abound in such large numbers that they pose a serious threat to human health. Their reproductive capacity is enormous and there may be ten to twelve generations in some seasons. Each female lays about two hundred to thousand eggs and the progeny of one female at the end of the eighth generation has been calculated to be 1,875,000,000,000. They feed on any liquid food substance, decaying vegetation, sputum, faecal matter, exposed meat, wounds of man and animals and therefore carry many disease producing germs. A peculiar habit of the house flies is to vomit a part of the liquid food taken in and when they do so on exposed food, facilitate the spread of disease producing organisms. Cockroaches are loathsome creatures which contaminate all food substances they come into contact with. They are also believed to be the carriers of skin diseases. Some caterpillars bear stinging hairs or spines which produce diseases of the skin. Some like the bees, wasps and ants sting very badly, causing inconvenience. The sting of the honey bee causes a painful sensation as a result of an acid and an alkali being forced down into the wound made by the sting. Some of the wasps attack man and give a ferocious sting. Some of the ants inflict pain by their jaws, but others possess stings which inject formic acid. Insects like the bed bugs, lice and fleas are external parasites and spread also the diseases of the skin. Others like the horse flies, stable flies and sucking lice cause great losses to cattle by feeding on the blood. Therefore the insects also play a major role in attacking man from every angle causing destruction not only to his food and crops, but also to his domestic animals and directly to man himself by causing diseases that result in death.

Turning to the beneficial insects, they oblige man in various ways such as producing useful products like silk, honey, lac and wax; by helping in the pollination of flowers and hence in the production of fruits; some insects like termites and locusts are eaten as food; some of them like the dung beetles help as scavengers, while several insects serve to fight and keep in control the undue multiplication of pests. Several insects feed on weeds and other plants which become a great nuisance. The commonest example is the prickly-pear which has been controlled by certain cotton covered bug-like insects. A number of insects live in the soil and serve to improve its texture and add humus. Insects are valuable pollinators of flowers. Bees, wasps, ants and butterflies are common pollinators. Insect pollination appears certainly a 'must' in agriculture and a good practice has been the introduction of permanent beehives near the vicinity of fields. This is because in many localities the number of pollinators are limited and these bees play an excellent role as pollinators. A particular variety of fig called the Smyrna fig depends entirely upon pollination by a tiny wasp to become a mature fruit.

Silk industry has flourished because the silk moths have been domesticated from time immemorial. In India we have several silk-rearing centres and the common silkworm called the mulberry silkworm is reared all over the world and produces a great bulk of the world's silk. A less common but nevertheless important silkworm in this country is the Eri silkworm or the Castor silkworm. The silk moths lay eggs on the leaves and the caterpillars coming out grow and feed and make the cocoon in which they pupate. The cocoon is made up of the saliva of the caterpillars which hardens when exposed to air and form fine threads of silk. The mulberry silk worm spins its cocoon by means of a single continuous thread of silk, whereas the cocoon of the Eri worm is not made of unbroken strand. It is estimated that it generally requires twenty-five thousand cocoons to make a pound of mulberry silk.

Honey bee is another example of a domesticated insect. For centuries honey and bees wax have been in use and in ancient days they were utilized even in the payment of taxes and as a ransom to conquered tribes. The nectar obtained from the flowers is mixed with saliva and swallowed and is carried to the beehive. There it is emptied into the hive cells through the mouth by the workers. Though a normal beehive produces fifty to hundred pounds of honey, in well maintained hives two hundred to four hundred pounds are possible. Hence on a commercial scale bee-keeping is a profitable business. Bees also secrete bees wax produced by glands under the abdomen and pour it in thin fine flakes. There is also another insect called the lac insect, which yields the shellac of commerce. It lives on various forest trees in large clusters and are cultivated to the extent of being transferred from one wild tree to another. The secretions of the crowded lac insect hardens and forms crusts or thick layers around the branches. These are called the stick-lac. The crusts are removed and crushed to get the seed lac. When the seed lac is melted we get the shell-lac. The lac insect provides material from which are obtained spirit varnishes, furniture polish, sealing wax, gramophone records, etc.

In addition to forming the food of many birds and animals, man has also taken to insects for food. Grasshoppers, termites, crickets and white ants and some caterpillars are believed to be delicacies in some parts of the world. Lastly the ornamental value of insects cannot be underestimated. Insects are proverbial for their brilliant colouration and the pleasing patterns in the butterflies, some beetles and plant bugs are known to all.

4

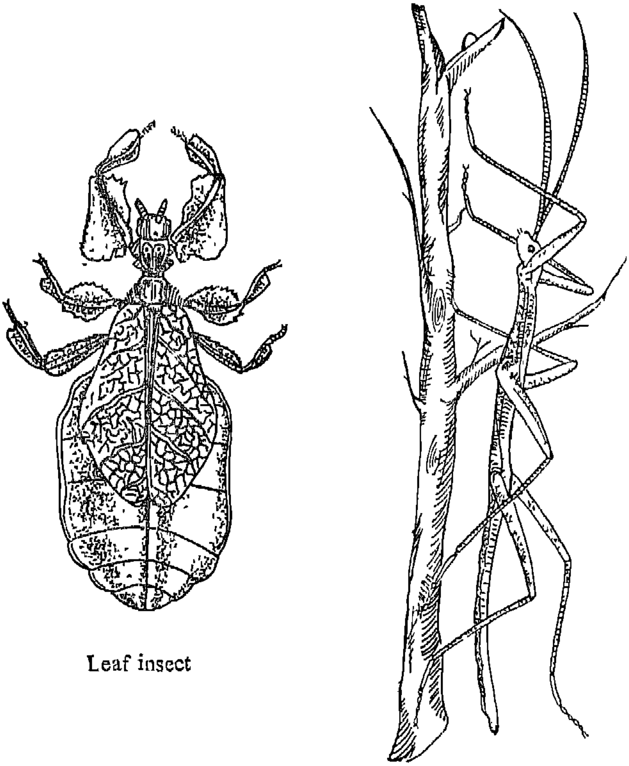
Protective Devices in Insects

NATURE appears to have insured some insects exposed to dangers of attack by other animals by providing them with subtle mechanisms for defence. In order to escape from such large predators as reptiles and birds, many insects like the butterflies and moths, leaf and stick insects, beetles and grasshoppers, tend to assume a concealed colouration, often resembling leaves and twigs. Many individuals at rest orient themselves to the sun in such a way that only a minimum area of their bodies is presented to the sun's rays. Sometimes two or more unrelated insects adopt similar patterns so that they appear very much alike. Yet others simulate the bold colour patterns of stinging insects, thereby giving a false impression of a harmful insect and avoid being recognised as harmless ones. By the release of toxic substances from the body, by pretending death, by adopting a threatening pose and by automatically shedding a limb or two on being trapped, many insects often evade a possible attack from their predators.

Matching of the background is the simplest form of protection. The common praying mantis usually green and greyish in colour, often waiting among vegetation to capture its prey, is a notable example. The slender, long green thorax resembles the stem or the flower stalk. In some the mid and the hind legs have flat, green, leaf-like expansions allowing them to hide among vegetation. The powerful forelegs held under the head which is turned from side to side, looking for an innocent passing insect, grasp it within the firm clutches of its forelegs.

The leaf and stick insects are better known for their perfect camouflage, often resembling twigs or leaves in both colour and appearance. The stick insect is very long and thin, with long, thin legs. The forelegs are stretched forwards so that they resemble the twigs more perfectly. When they thus sit motionless among twigs they easily escape being recognised. The leaf insects on the other hand are more flattened and totally resemble a leaf. Individuals living among green leaves have green wings, while those living among dead leaves have brownish wings. The leaf insect has perfected its resemblance to a leaf because its abdomen is flat and spread out, legs leaf-like and wings clearly marked with veins as on a leaf. Above all, the leaf insect also lays eggs which look exactly like seeds (Fig. 15).

Striking instances of insects matching their colour with the background are met with among butterflies and moths. Many moths imitate or mimic dead leaves by presenting a longitudinal stripe from tip to tip, so as to look like the midrib of a leaf. Some have the edges of their wings worn or eaten out so as to appear like worn-out leaves. Some others copy such leaf patterns as the moulds or rusts or holes often seen on dead leaves. Several moths have greyish white to dark patterns resembling the barks of trees. Invariably the hind wings of such forms are brilliantly coloured, while the front pair dull



Leaf insect

Fig. 15. Stick insect

coloured, so that when they rest on the bark or on dead leaves the front wings cover the hind ones. This helps the individuals being unrecognised by predators like birds. One of the finest examples of camouflage is seen in the Indian dead leaf butterfly *Kallima* (Fig. 16). This butterfly when it sits with wings folded besides dried leaves, looks a hundred per cent like them. This butterfly has vivid colours on the upper surface of the wings but the under surface is brown. The patterns on the under surface are perfectly similar to the veins on the dry

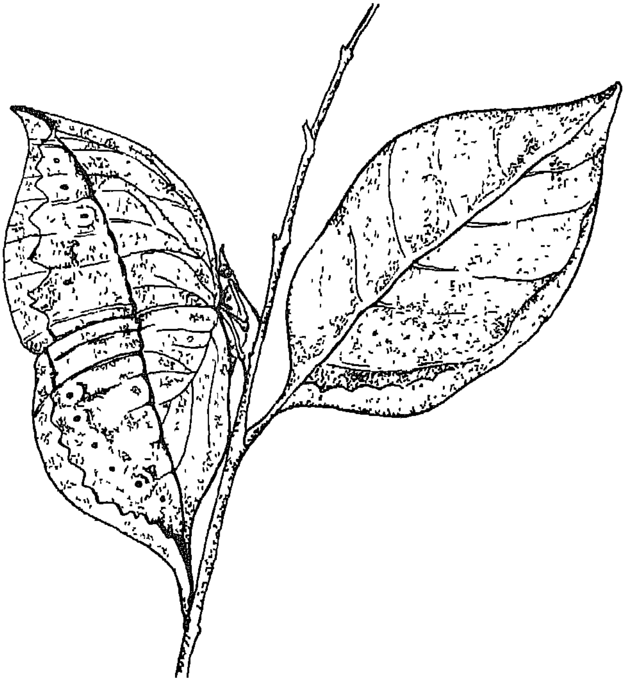


Fig. 16. Dead leaf butterfly

leaves. The extended portion of the lower wings looking like the tail, resembles the leaf stalk, while the marks on the surface looks like fungal spots or leaf rust common on dead leaves. The caterpillars of some moths are twig-like and to discover them quickly is not so easy. Both in colour and in actual form they combine a close resemblance to twigs. In addition, they lie rigid and lifeless during the day to escape notice of their enemies.

Another category of insects adopts a different attitude for purposes of defence by assuming a threatening pose, fully exposing their strikingly bold colour patterns to drive away the intruders. One of the usual colour combinations for parading in a warning colour uniform is black and yellow. Many moths have perfect, circular, eye-like markings on the hindwings in addition to being gorgeously coloured. By constantly exposing these eye marks, by raising the forewings even while at rest, they create a threatening attitude, as if staring at the intruder Some butterflies and moths which are very tasty or palatable to birds and other animals, deceive their enemies by closely imitating the colour patterns of those which are unpleasant to taste. A few harmless insects like flies or beetles or small moths assume the bold colour patterns of stinging wasps and thereby give a false indication of a harmful stinger. Some carnivorous flies, called the robber flies, resemble very remarkably some bees in their colour and shape. This enables them to move about freely among the bees and devour their young ones.

Feigning death when disturbed and by the instantaneous shedding of a limb or two, many insects defend themselves from attack. The 'skip-jack' or the click beetle is a good example of an insect remaining motionless for a considerable period, when disturbed. It draws its antennae and legs close to the body and in addition, the more or less rounded body shape makes it look exactly like a seed or a pebble. After sometime, it stretches and gets off with a click, jerking itself into the air. By this gymnastic capacity of dropping to the ground and landing on its back to feign death and then leaping into the air, these beetles have acquired a means of escape. Sometimes as in the stick insects, there is an adaptation whereby the frightened insect allows itself to fall to the ground and pretend to be dead. Their ability to detach or shed a leg or two when they get trapped is also an escaping device. The lost limbs are soon replaced by regeneration particularly if this occurs in one of the earlier stages of development.

Apart from being provided with stings to defend themselves by injecting a poisonous liquid into the enemy and causing pain or death, many insects possess stinging hairs. Several others protect themselves by chemical means, by making good use of the secretions of the glands of their own body. The common bombardier beetle is a good example and they are so called because they eject this secretion from glands at the tip of their abdomen, with a sharp, explosive sound, resulting in a miniature cloud of the secretion. The bombardier spray is due to an internal explosion as a result of chemical changes brought about by the secretions of the glands. These secretions are stored in a reservoir in the abdomen and released into an adjacent explosion chamber, where the reaction takes place, resulting in an explosive sound. This beetle has been known to repeatedly cause the explosion in rapid succession. There are also some ants which cannot sting, but can squirt formic acid from glands at the end of their body to a distance of more than a foot. Some lady bird beetles have the power to make drops of blood ooze from their body, thereby making the external surface of the insect very unpleasant to taste. Others like the stink-bugs are endowed with a foul smell. The secretions of these bugs are so foul-smelling that the predators never get near them. Many moths match very well the bark of trees and more so to lichens on them and get protected from moth eating birds. In recent years heavy industrialisation in many parts of the world, has resulted in the blackening of the exposed parts of trees by smoke. As such the moths resting fully exposed on the tree trunks have also undergone considerable darkening to match the dark background. This phenomenon has been called industrial melanism.

Innumerable examples depicting the endless techniques adopted by insects for survival exist. Some have two or more lines of defence, each being as efficient as the other. When these multiple defence systems occur in any insect, each of them comes into play in succession to add to the aggressive attitude, if occasion demands it.

5

Insect Control

IT WAS emphasised in earlier chapters that insects not only compete with man for food and shelter, but also transmit diseases to man, animals and crop plants. In order to provide sufficient food for the ever increasing human population and to protect the health of man and domestic animals, these insects should be kept in check from undue multiplication. We use the term 'Pest Control' for this process of keeping down the harm caused by insect pests and thereby attaining protection from them. Several methods of insect control are now in use, and they could be broadly classified as natural control and artificial control methods. Natural control is what takes place in nature, such as through the action of climatic factors, predators and parasites and through the disease producing organisms of insects themselves. Artificial control is however influenced by man and involves the use of poisonous chemical compounds, usually called insecticides.

The early use of chemicals in the control of insects, consisted in using stomach poisons like lead arsenate for insects with biting mouth parts, like cockroaches, grasshoppers, caterpillars, etc. Spraying nicotine or tobacco decoction for insects with sucking mouth parts and fumigation with gases like hydrogen cyanide for insects affecting stored food products, were also in use. The discovery of the wonder chemical DDT in 1940 was a great step in insect control, because its greatest achievement was in the total control of the malarial mosquitoes. Besides, it was effective against almost all pests. However, with the desire of achieving quicker results, much more stronger insecticides were produced in recent years. These are commonly known to all farmers by the names Endrin, Parathion, Malathion, etc. They have not only the property of killing outright all the insect pests, but also of being harmful to man and animals. By consuming vegetables from plants treated with these insecticides, man becomes susceptible to the effects of poisoning. Even birds and other animals eating seeds or fruits of plants treated with these insecticides die of poisoning. There is also another danger in using these insecticides, because they also kill the beneficial parasites and predators, which help to keep down the multiplication of some pests. The development of resistance to some of these insecticides by insects is another problem that is facing us. Therefore, a combination of different methods of control appears helpful.

Biological control is one of the natural control methods, involving the use of the natural enemies of insect pests such as the predators and parasites. This method consists in the mass rearing of these natural enemies and releasing them in large numbers in the fields. The parasites are usually smaller than the host and brings about the death of the host by slow torture. The host is not immediately killed, but is forced to supply food to the developing young within its body. Among predators, some hunt for their prey and kill them outright as in the case of dragonflies. Others like the lady bird beetles feed on specific insects (Fig. 17) ; yet others like the wasps are called the stinging predators. These instead of killing the prey outright, sting the victims and paralyse them by means of their powerful sting and carry the prey to their nest to serve as food to the developing young.

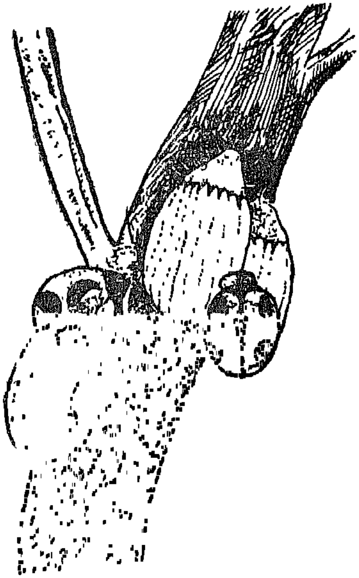
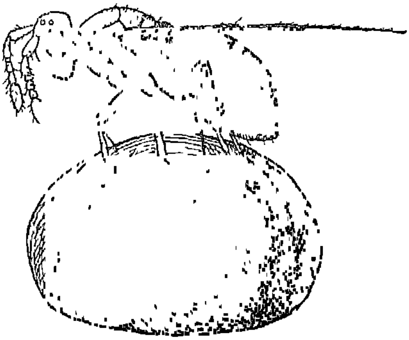


Fig. 17
Lady bird beetles feeding on scale insects

Coming to the utilization of parasites in biological control, we have the famous example of the coconut caterpillar, a very serious pest of coconut palms all over Kerala being controlled to some extent by a tiny egg parasite. This egg parasite is a tiny wasp which lays its eggs within those of the host with the result that instead of caterpillars coming out, we have the young ones of the wasp emerging. There are numerous similar examples of parasitization by these tiny wasps of the eggs and larvae of several other insect pests (Fig. 18).



Egg parasite

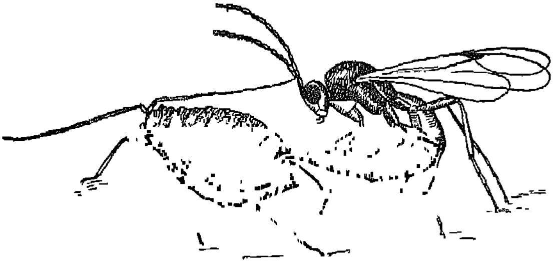


Fig. 18 Wasp parasitizing Aphid

Not only do insects play a part in controlling other insect pests but they also play an equally great role in the control of harmful weeds which obstruct cultivation in fields and navigation in water. To mention a local example, the prickly-pear once extending into acres and acres of arable and pasture lands and making a heavy toll the farmer toil hard to keep them within bounds, has now been successfully controlled after the introduction of its natural enemy. This insect is commonly called the cotton cushion scale or the cochineal insect, related to the plant lice and seen as whitish patches of cottony matter on the pricklypear plants. As a result of continuous sucking by huge colonies of these insects, the plants dry up resulting in the total absence of the pricklypear plant from many localities (Fig. 19).

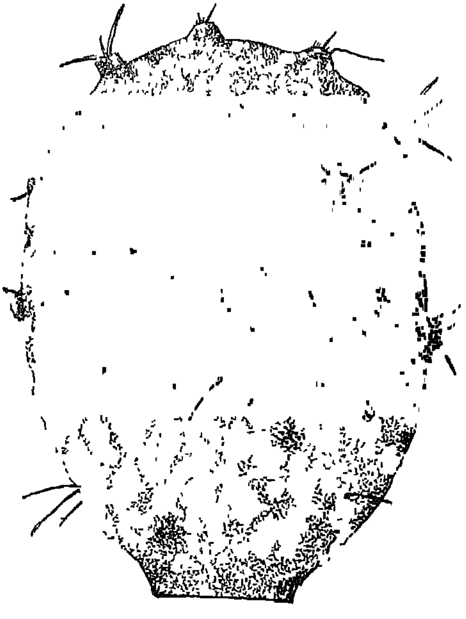


Fig. 19. Cochineal Insect on Pricklypear

Besides the biological and chemical control methods, several other methods of keeping insects within bounds are now practised. One of these is the cultivation of plants resistant to insect attacks. A good example is seen in the cotton plant which in some places was threatened to destruction by leafhoppers. Examination of all the plants in a field showed that while most of the plants were attacked, only a few escaped damage. This was found to be due to the presence of hairs on the plant. Because, these hairs were a fraction larger than the sucking mouth parts, the leafhoppers were unable to feed on the leaves.

This gave a clue to the breeders to isolate these cotton plants and breed a whole race of cotton plants with hairs long enough to keep the leaf hoppers out.

Insects also suffer from diseases as other animals do. These diseases may be bacterial, fungal or viral. By utilising these pathogens or disease producing microbes, i.e., by multiplying them in large numbers and distributing in fields, insects could be controlled because these pathogens infect the insects and cause their death. Many of these pathogens could be distributed in water suspensions or as dry spores over large areas. Other modern methods of control involve sexual sterilization through irradiation or by the usage of certain strong chemicals called chemosterilants which cause sterility in both sexes.

6

Insect Collection as A Hobby

ONE WITH a natural taste for the splendours of nature cannot resist the temptation of getting out doors into fields, forests, hills and streams to observe, learn and enjoy all about living organisms. Not only is it a stimulating pastime, but it also provides opportunities to gain a first-hand knowledge of the relation of the animals and plants to their immediate surroundings, the periodicity of their occurrence and their life cycles. Collection and study of insects as a hobby has been the favourite pastime of many a young and old students and laymen. Apart from being merely a collector, years of accumulation of material collected would provide opportunities for extensive studies particularly on such insects as the dragonflies, butterflies, moths and beetles. Insects abound everywhere, but unless one knows where to look for them, even hours of wandering would be futile. It is here that the trained eye is able to recognise the immense wealth of insects. Apart from occurring on all types of vegetation and in all the plant parts, they occur in debris, leaf mould, leaf litter, rotting fungi and other decaying animal and vegetable matter. They are strongly attracted to light and can even be collected at street lamps. Many occur in ponds, pools, lakes and flowing streams. Some of them walk on the water surface, or are free swimming, others move about on submerged vegetation and still others occur beneath stones under water. A knowledge of the preferred habitats is therefore essential before one attempts to collect insects.

Every one interested in the collection of insects has to equip himself with some inexpensive collecting tools. These include insect nets, aspirators, killing bottles, forceps, handlens, etc. The common insect net consists of a light and strong handle about a yard long and fitted with a stiff wire rim or hoop to which a cloth bag is attached. The cloth may be twice as long as the diameter of the rim. Two types of nets are usually carried, viz., the sweep net and the aerial net or butterfly net. The sweep net is used to sweep all kinds of vegetation to collect different kinds of insects on them. This net should be strong and the cloth bag should be of comparatively thick material. The light net is used to collect butterflies, dragonflies, wasps, etc. The cloth bag in this case should be a fine porous material like that of a fine mosquito net (Fig. 20).

For collecting small insects, a simple aspirator is used. It consists of an ordinary glass vial with a double holed cork. Insects are drawn into the vial through a bent tube after sucking through the mouth piece which is a short tube to which is attached a rubber tubing

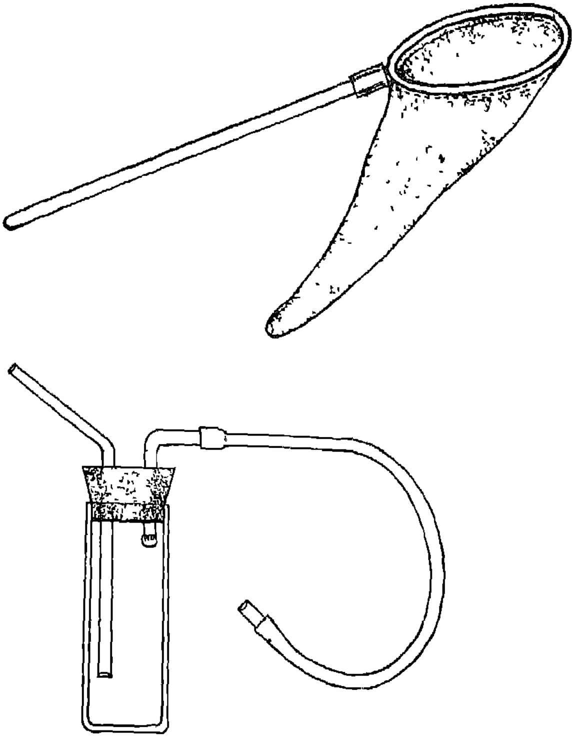


Fig. 20. Collecting net and Aspirator

Light traps are also used to collect insects. A simple trap is to hang a white piece of cloth with the light shining against it. As the insects collect on the sheet they are picked up and preserved.

After collecting the specimens they should be killed within a reasonable time in a killing bottle so as to avoid damage to the insects. The most widely used chemical in the killing bottle is calcium cyanide or potassium cyanide. This is placed at the bottom of the killing jar A layer of Plaster of Paris half an inch thick is added to it. The bottle must be labelled 'POISON' because cyanide is a deadly poison, and must be handled with care. A separate bottle must be used for different groups of insects and particularly for the butterflies and moths.

A safer method is to use a killing jar containing ethyl acetate. At the bottom of the jar is placed a mixture of Plaster of Paris and water. When set or dried fully, it is saturated with ethyl acetate.

For purposes of preservation of small soft bodied insects 70-80% alcohol or 4% formaldehyde is used. Others like the beetles, butterflies and moths are mounted on non-rust insect pins specially made for this purpose. Butterflies and moths are mounted with wings spread and for this purpose spreading boards (Fig. 21) form an essential item of every collector. These are made of soft wood to facilitate proper insertion of pins.

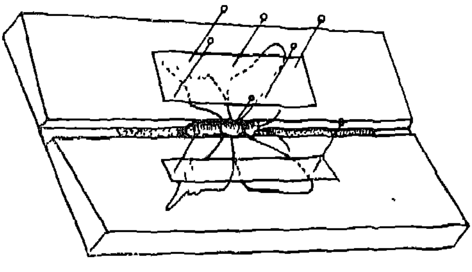


Fig. 21. Spreading board for butterflies

Suggestions for Follow-up Reading

1 *The Insects* by PETER FARBE, Life-Nature Library (1962)

2. *Insect Natural History* by A D. IMMS; Collins, London (1956)

3. *Insects and Their World* by HAROLD OLDROYD; British Museum of Natural History Publication (1960)

4. *Collecting, Preserving and Studying Insects* by HAROLD OLDROYD, Macmillan & Co. (1957)

5. *Parade of Animal Kingdom* by ROBERT HEGNER Macmillan & Co. (1946)